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USING **SHUMP** TO DISPLAY SHIP HULLS, PROPELLERS AND FLOW FIELDS

David Hally

Defence Research Establishment Atlantic

Centre de Recherches pour la Défense Atlantique

Canada

DEFENCE RESEARCH ESTABLISHMENT ATLANTIC
9 GROVE STREET
P O. BOX 1012
DARTMOUTH, N.S.
B2Y 3Z7

TELEPHONE
(902) 426-3100

CENTRE DE RECHERCHES POUR LA DÉFENSE ATLANTIQUE
9 GROVE STREET
DARTMOUTH
B2Y 3Z7

Abstract

SHUMP is a graphics program which displays three-dimensional scenes built from a hierarchy of simple objects: points, lines, panels, and so on. In this document two additional computer programs are described; they create SHUMP input files which display propellers, ship hulls, and the flows around them.

PRPPNL generates a SHUMP input file which includes a single propeller with the option of adding sheet cavitation extents on the back of each blade. The display may be animated to show the variation of cavitation as the propeller turns. The propeller geometry is obtained from the DREA propeller geometry database, while cavitation extents are those predicted by the computer program CAVITY.

HLLPNL generates a SHUMP input file which may include the hull, its propellers including sheet cavitation extents, streamlines, a surface at the edge of the boundary layer, shaded plots of boundary layer parameters at the hull surface, and displays of the flow field around the hull. The hull geometry is obtained from a HLLSRF representation, while the flow around it is obtained from the suite of computer programs HLLFLO.

Résumé

Le logiciel SHUMP est un programme graphique qui produit des scènes à trois dimensions à partir d'un certain nombre d'objets simples, classés par ordre de complexité, soit des points, des lignes, des panneaux, etc. Dans le présent document, il sera question de deux nouveaux programmes de ce type, qui permettent la création de fichiers d'entrée SHUMP, grâce auxquels on peut obtenir des images virtuelles d'hélices marines, de coques de navires ainsi qu'une visualisation de l'écoulement de l'eau autour des pales d'hélice ou des parois de coque.

Les fichiers d'entrée SHUMP sont générés par le système PRPPNL, qui produit l'image d'une hélice unique, avec cependant la possibilité d'ajouter (en option) une visualisation de l'effet de cavitation laminaire derrière chaque pale. Ces images peuvent être animées pour bien montrer les variations de la cavitation, avec la rotation de l'hélice. Les données relatives à la géométrie de l'hélice proviennent de la base de données de géométrie d'hélice du CRDA, alors que les données de cavitation ont été calculées par le logiciel CAVITY.

Le système HLLPNL génère le fichier d'entrée SHUMP, capable d'englober les données relatives à la coque et à ses hélices, y compris l'étendue de la cavitation laminaire, et d'assurer la visualisation de filets d'eau, des lignes hydrodynamiques, d'une surface donnée au bord de la couche limite, de reprsentations graphiques ombrées des paramètres de la couche limite à la surface de la coque ainsi que des lignes de force du champ de propagation autour de cette dernière. Les données de géométrie de la coque proviennent d'une représentation HLLSRF, alors que celles du champ de propagation autour de la coque proviennent de la famille de logiciels HLLFLO.

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1 Introduction

SHUMP is a graphics program which displays three-dimensional scenes built from a hierarchy of simple objects: points, lines, panels, and so on. This document describes how SHUMP can be used to display ship hulls, the flow field around them, and propellers. The displays are generated from HLLSRF hull representations[1], from the DREA propeller geometry database, from the output of the DREA program suite HLLFLO[2], and from the cavitation prediction program CAVITY[3].

Since SHUMP does not understand anything about ship hulls, flows, or HLLFLO output files, it is necessary to have intermediary programs which convert HLLFLO and CAVITY output to SHUMP input. Two such programs are described here.

PRPPNL generates a SHUMP input file which includes a single propeller with the option of adding sheet cavitation extents on the back of each blade. The display may be animated to show the variation of cavitation as the propeller turns. Section 2 is a user's guide to the program PRPPNL.

HLLPNL generates a SHUMP input file which may include the hull, its propellers including sheet cavitation extents, streamlines, a surface at the edge of the boundary layer, shaded plots of boundary layer parameters at the hull surface, and displays of the flow field around the hull. Section 3 is a user's guide to the program HLLPNL.

2 PRPPNL User's Guide

PRPPNL is a program for creating SHUMP displays of propellers and sheet cavitation on them. The propeller geometry is obtained from the DREA propeller geometry database. The cavitation is determined from the output of the propeller cavitation prediction program CAVITY. The SHUMP display is animated, showing the development of the cavitation on each blade as it turns. Figure 1 is an example of the display.

PRPPNL uses a command language to allow you to direct the creation of the propeller display. The command language is implemented using the GETWRD Package[4]. It is described in Appendix A.

2.1 Running PRPPNL

When PRPPNL is invoked, the following prompt is written.

```
Entering PRPPNL ...

Enter name of file for output =>
```

Type the name you wish to use for the output file. If you do not give the file name an extension, the extension `.pnl` will be added.

You will then be prompted for the name of the file which contains the geometry of the propeller which you wish to display.

```
Enter the name of the propeller data base file =>
```

When the file has been read, PRPPNL prints the origin, designation, and description fields from the file. If there is more than one propeller described in the file, PRPPNL will read the first one; there is currently no method for searching among several propellers in the file. See Appendix B for instructions on how to set up a list of directories in which PRPPNL will search for files.

After the propeller geometry file has been read, PRPPNL needs to know the values of parameters which it uses to create the SHUMP display. All the parameters have default values which are displayed on the screen at this time. It then types the prompt

```
propeller =>
```

to indicate that it is waiting for your commands to change the parameters.

The command

```
=>CANCEL
```

will quit the program without writing anything into the output file.

If you wish to add cavitation extents to the display, use the command

```
propeller =>CAVITATION file-name
```

where *file-name* is the name of the file containing the cavitation data. This file is the output file created by the program CAVITY[3] and initially called CVPLOT.ASC.

If you wish to create a propeller in which only one blade is shown, use the command

```
propeller =>SINGLE-BLADE TRUE
```

If you later wish to change the display so that all blades are shown, give the command

```
propeller =>SINGLE-BLADE FALSE
```

By default, the propeller in the display will be animated, turning upon its axis. If you wish it to be still, use the command

```
propeller =>ANIMATION OFF
```

You may turn the animation back on again with

```
propeller =>ANIMATION ON
```

Of course, the animation can also be controlled from within SHUMP; the animation flags set by PRPPNL only control the animation in SHUMP's initial display.

Each face of a propeller blade is described in the output file by a rectangular grid of points. The dimensions of the grid may be changed by the commands

```
propeller =>CHORDWISE-NUMBER number
```

and

```
propeller =>RADIAL-NUMBER number
```

By default, the points used will be those read from the propeller geometry file. If the dimensions of the grid are changed, PRPPNL interpolates to obtain the correct number of new points.

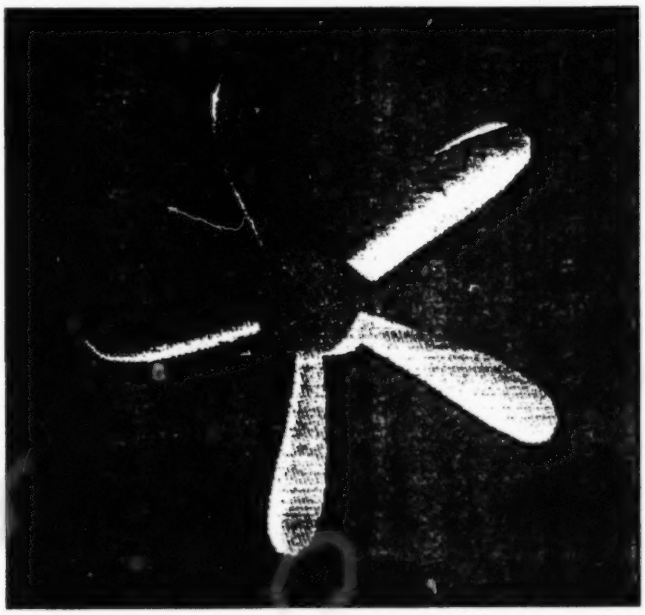

Figure 1: *The SHUMP display of a propeller with cavitation as generated by the program PRPPNL.*

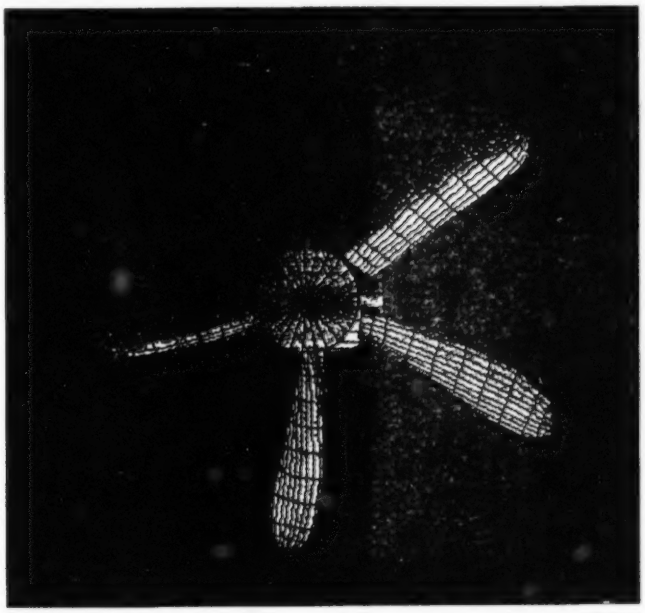

Figure 2: *The propeller of Figure 1 displayed in* `WIRE-EDGES` *display mode*

SHUMP uses 'material properties' defined by the Silicon Graphics GL library in order to describe how an object will look. The material properties of the propeller may be changed by giving the command

```
propeller =>MATERIAL
```

The prompt

```
material =>
```

then appears, indicating that PRPPNL is waiting for you to define the new material. See Section 4 for a description of the appropriate commands. The default material for the propeller and its hub is brassy in appearance.

SHUMP can display the propeller in five different ways; moreover, it is possible to choose a different mode of display for when you are moving the propeller with the mouse, and for when you are not. The command

`propeller =>MOVING-DISPLAY-MODE` *display-mode*

chooses the display mode for when the propeller is being moved.

`propeller =>NORMAL-DISPLAY-MODE` *display-mode*

chooses the display mode for when the propeller is not being moved. Section 5 describes the choices for *display-mode*. Note that if the propeller is turning because it is animated, but you are not moving it with the mouse, then the normal display mode is used. That is, the moving display mode is not used whenever the propeller is moving; rather, it is used only when the propeller is being moved by mouse manipulation.

Figure 1 shows an example of the default display mode (`SMOOTH`) for the propeller; Figure 2 shows the propeller displayed using the `WIRE-EDGES` display mode.

Each SHUMP object may be turned on (i.e. it will be displayed) or off. You may control the state of the propeller (on or off) using the commands

```
propeller =>ON
```

and

```
propeller =>OFF
```

The default state is 'on'. If you wish only to view the propeller in isolation, it is very unlikely that you will wish to turn it off; however, if the propeller file is to be included into a more complex display, it might be desirable to have it turned off.

At any time, you may view the values of the display parameters by giving the command

```
propeller =>REPORT
```

Once the parameters have been set to your satisfaction, give the command

```
propeller =>OK
```

PRPPNL will write the display into the output file, then quit.

3 HLLPNL User's Guide

HLLPNL is a program for creating SHUMP displays of ship hulls and the flows around them. The hull geometry is obtained from a HLLSRF representation[1]. The flow is obtained from output files generated by the HLLFLO suite of flow programs[2]. Section 3.1 describes the required files in more detail.

The SHUMP displays created by HLLPNL may include the hull, its propellers including sheet cavitation extents, streamlines, a surface at the edge of the boundary layer, shaded plots of boundary layer parameters at the hull surface, and displays of the flow field around the hull.

Figures 3 and 4 are examples of SHUMP displays created using HLLPNL. Figure 3 includes a hull, propellers, waterplane, and streamlines; the line of sight is from the bow looking astern. Figure 4 includes the hull, waterplane, boundary layer surface, and propeller disks; the line of sight is from the stern looking forward.

3.1 Data Files

Different displayed objects require different input files. Whenever you add an object to the display, HLLPNL checks to see that all appropriate data files have been read. If, one has not, you will be prompted for it. The following files may be required.

1. HLLSRF data files: These files contain HLLSRF representations of hulls; Reference 1 describes the HLLSRF representation including a description of the file format. HLLSRF data files usually have the extension `.hll`. If HLLPNL prompts you for the name of a HLLSRF data file, you need not include the extension `.hll`; it will be added automatically if the file name has no extension.

   HLLSRF data files can be created using the HLLFLO program HLLSPL[5]l they can be modified using the program MODHLL[6].

2. Velocity data files: These files contain a representation of the potential flow at the surface of the hull. Velocity data files usually have the extension `.vel`. If HLLPNL prompts you for the name of a velocity data file, you need not include the extension `.vel`; it will be added automatically if the file name has no extension. Velocity data files are created using the POTFLO program VELSPL (Reference 2, Section 16.10). The format of velocity data files is described in Reference 2, Appendix B.

3. Boundary layer data files: These files contain a representation of the boundary layer over the hull. Boundary layer data files usually have the extension `.bly`. If HLLPNL prompts you for the name of a boundary layer data file, you need not include the extension `.bly`; it will be added automatically if the file name has no extension.

   Boundary layer data files are created using the program BLAYER (Reference 2, Section 6). The format of boundary layer data files is described in Reference 2, Appendix C.

4. POTFLO data files: If a flow block is to be added to the display (see Section 3.9), then the POTFLO files RGRID.POT, RSOURC.POT, and PANPRP.POT are required for

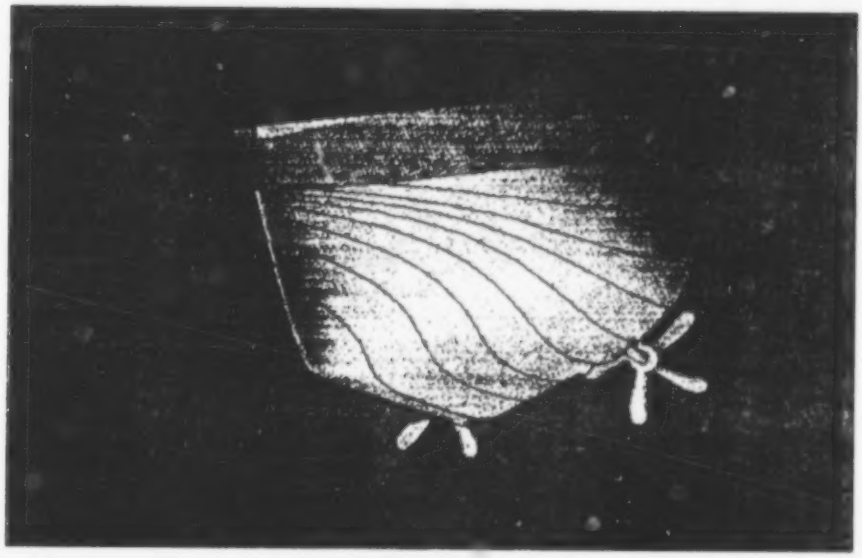

Figure 3: *An example of a HLLPNL display including the hull, propellers, a waterplane, and streamlines.*

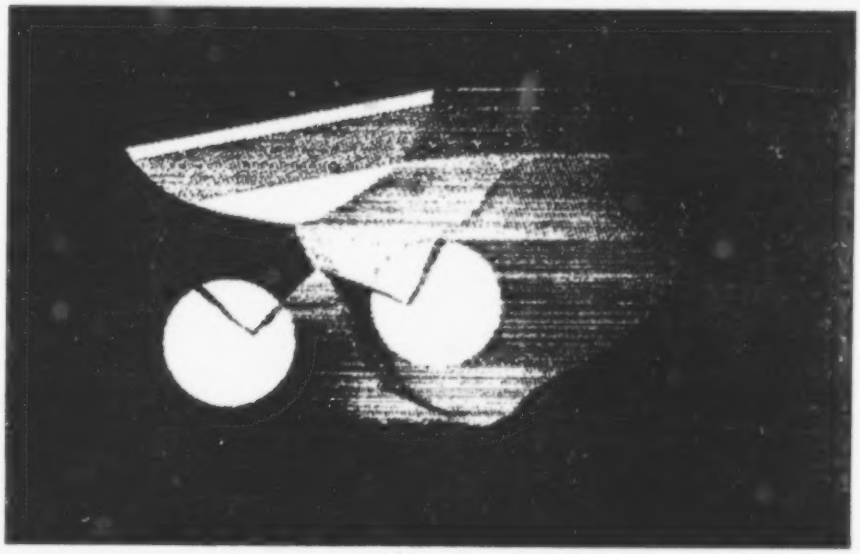

Figure 4: *An example of a HLLPNL display including the hull, the boundary layer surface, a waterplane, and propeller disks.*

the calculation of the flow at off-hull points. These files are described in Reference 2, Section 16.4.

In HLLPNL, the maximum length for a file name is sixty characters.

3.2 Running HLLPNL

When HLLPNL is invoked, the following prompt is written.

```
Entering HLLPNL ...

Enter name of file for output =>
```

Type the name you wish to use for the output file. If you do not give the file name an extension, the extension .pnl will be added.

HLLPNL then displays the prompt

```
=>
```

to indicate that it is waiting for your commands. Like PRPPNL, HLLPNL runs in two stages: first you give commands to indicate what you want included in the display and to set values of parameters for those objects; then you give the command `OK` and HLLPNL creates the display in the output file.

To add an object to the display give the command

`=>ADD` *object*

You then enter a sub-command language which allows you to set the values of the parameters for *object*. The parameters for each object are described in Sections 3.3–3.9. The command

```
=>ADD ALL
```

will cause all the objects to be added to the display. They will each be given default values for all of their parameters. You may later change the values for any object by using the `ADD` command again to enter the sub-command language for that object.

To remove an object from the display, use the command

`=>REMOVE` *object*

All the objects can be removed from the display using

```
=>REMOVE ALL
```

To get a report on which objects are added to the display and which are not, use the command

```
=>REPORT
```

To change either the HLLSRF data file, the velocity data file, or the boundary layer data file, use the command

`=>FILE` *type name*

where *type* is one of BOUNDARY-LAYER, HULL-SPLINE-COEFS, or VELOC-SPLINE-COEFS and *name* is the name of the file.

To exit from HLLPNL without creating a display, use the command

```
=>CANCEL
```

3.3 Adding a Hull

To add a hull to the display, use the command

```
=>ADD HULL
```

A report of all the default values for the hull parameters is displayed, followed by the prompt

```
hull =>
```

The word hull to the left of the arrow indicates that you are now using the hull sub-command language and that HLLPNL now expects you to adjust the hull parameters to your liking. When you are done, give the command

```
hull =>OK
```

If a HLLSRF data file has not already been read, you will be prompted for one. Control then returns to the top level commands. Note that the hull display is not written to the file until the command OK is given at the top level of commands.

If you decide not to include the hull after all, use the command

```
hull =>CANCEL
```

to return control to the top level commands.

The hull is described in the output file by a rectangular grid of panels. The panels only describe one half of the hull; they are then reflected in the centreplane to create the other half. The dimensions of the grid may be changed by the commands

```
hull =>BOW-TO-STERN-NUMBER number
```

and

```
hull =>GIRTH-NUMBER number
```

By default, the number of panels bow-to-stern will be 20 and the number around the girth will be 10.

SHUMP uses 'material properties' defined by the Silicon Graphics GL library in order to describe how an object will look. The material properties of the hull can be changed using the command

```
hull =>MATERIAL
```

The prompt

```
material =>
```

then appears, indicating that HLLPNL is waiting for you to define the new material. See Section 4 for a description of the appropriate commands. By default, HLLPNL will not define

a hull material; SHUMP will then choose the material properties at random.

Like propellers, SHUMP can display the hull in five different ways. The normal and moving display modes may be set using the commands

`hull =>MOVING-DISPLAY-MODE` *display-mode*

and

`hull =>NORMAL-DISPLAY-MODE` *display-mode*

Section 5 describes the choices for *display mode*. The default for both the normal and moving display mode is `SMOOTH`.

You may control the state of the hull (on or off) using the commands

```
hull =>ON
```

and

```
hull =>OFF
```

The default state is 'on'. It is unlikely that you will wish to turn the hull off.

At any time, you may view the values of the hull display parameters by giving the command

```
hull =>REPORT
```

3.4 Adding Propellers and Cavitation Extents

HLLPNL can add a propeller to the display, mounting at its correct position at the ends of a propeller shaft. In order to do this, the HLLSRF representation of the hull must include a description of the propeller disk (otherwise HLLPNL will not know where to place the propeller). If the propeller location is off the centreplane, HLLPNL assumes a twin-screw ship and adds two propellers, one of which is a mirror image of the other in the centreplane. Figure 3 is an example of a display which includes the propellers.

If no propeller is added, but the HLLSRF file includes a description of the propeller disk, then HLLPNL will automatically add a propeller disk to the display. This serves to indicate the position of the propellers, if not their shape. Figure 4 is an example of a display which includes the propeller disks. It also includes the boundary layer surface (see Section 3.7) which can clearly be seen to intersect the propeller disks.

To add a propeller to the display, use the command

```
=>ADD PROPELLER
```

If a propeller geometry file has not already been read, you will be prompted for one now. When the file has been read, a report of the default values for all the propeller parameters is displayed, followed by the prompt

```
propeller =>
```

The commands to change the propeller in HLLPNL are exactly the same as those in PRPPNL: see Section 2.1.

3.5 Adding a Waterplane

The waterplane is a single transparent rectangle placed at the position of the water surface. Figures 3–5 and 8 are examples of displays including a waterplane. To add a waterplane to the display, use the command

```
=>ADD WATERPLANE
```

A report of the default values for the waterplane is displayed, followed by the prompt

```
waterplane =>
```

HLLPNL now expects you to adjust the waterplane parameters to your liking. When you are done, give the command

```
waterplane =>OK
```

If a HLLSRF data file has not already been read, you will be prompted for one. Control then returns to the top level commands.

If you decide not to include the waterplane after all, use the command

```
waterplane =>CANCEL
```

to return control to the top level commands.

To change the transparency of the waterplane use the command

```
waterplane =>TRANSPARENCY level
```

where *level* is an integer between zero and 16; zero is opaque, 16 is completely transparent (invisible). The default transparency level is 8.

To change the material properties of the waterplane, use the command

```
waterplane =>MATERIAL
```

See Section 4 for a description of the appropriate sub-commands. The default waterplane is light blue and quite shiny.

You may control the state of the waterplane (on or off) using the commands

```
waterplane =>ON
```

and

```
waterplane =>OFF
```

The default state is 'on'.

At any time, you may view the values of the waterplane display parameters by giving the command

```
waterplane =>REPORT
```

3.6 Adding Streamlines

Two types of streamlines can be added to the display at the hull surface: the potential flow streamlines, which are the streamlines predicted by a potential flow calculation without

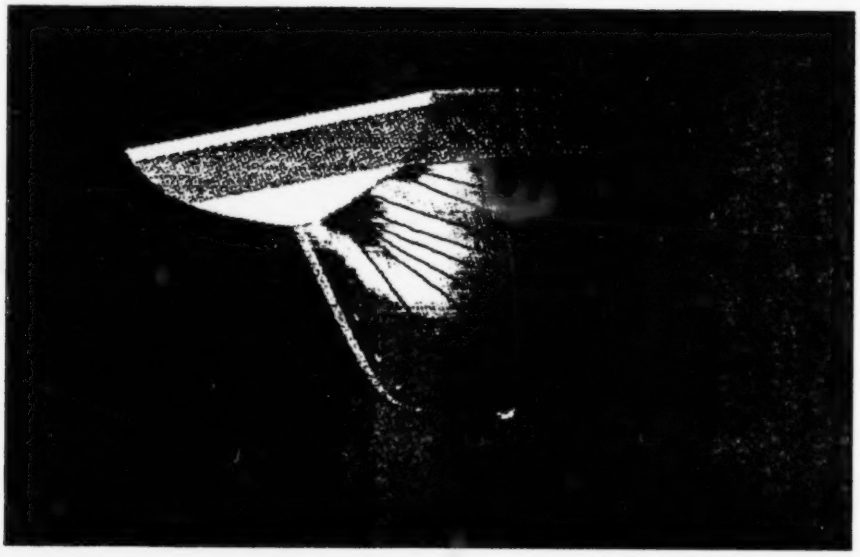

Figure 5: *An example of a HLLPNL display including the hull, a waterplane, streamlines, and a boundary layer block. The boundary layer block is displaying the momentum thickness; low values are shown in red, high values in blue.*

boundary layer corrections; and the limiting streamlines, which are the streamlines predicted taking the flow of the boundary layer into account.

Figure 3 is an example of a display which includes the potential flow streamlines. Figure 5 shows a display with limiting streamlines. This figure also includes a boundary layer block (see Section 3.8) showing a coloured display of the momentum thickness. It is easy to see that the momentum thickness increases (regions of blue) where the limiting streamlines converge.

To add streamlines to the display use the command

```
=>ADD POTENTIAL-STREAMLINES
```

or

```
=>ADD LIMITING-STREAMLINES
```

A report of the default values for the streamlines is displayed, followed by the prompt

type `streamlines =>`

Here *type* is either `potential` or `limiting` depending on the type of streamlines which you are adding. HLLPNL now expects you to adjust the streamline parameters to your liking. When you are done, give the command

type `streamlines =>OK`

The potential streamlines require data from a HLLSRF data file and a velocity data file. The limiting streamlines also require data from a boundary layer data file. If any of these files have

not already been read, you will be prompted for them now. Control then returns to the top level commands.

If you decide not to include the streamlines after all, use the command

type `streamlines =>CANCEL`

to return control to the top level commands.

The number of streamlines added can be changed using the command

type `streamlines =>NUMBER` *number*

where *number* is the number of streamlines displayed on the half-hull. The total number of streamlines is twice this number.

The colour of the streamlines can be changed using the command

type `streamlines =>COLOUR` *number*

where *number* is a number between zero and one: red is zero, green is 0.5, and blue is 1.0. By default the potential streamlines will be red and the limiting streamlines will be blue.

SHUMP can display the streamlines in three different ways. The normal and moving display modes may be set using the commands

type `streamlines =>MOVING-DISPLAY-MODE` *display-mode*

and

type `streamlines =>NORMAL-DISPLAY-MODE` *display-mode*

You have the following choices for *display mode*:

`SOLID`: This is the standard display mode in which the streamlines appear as solid lines. It is the default for both normal and moving display modes for both potential and limiting streamlines.

`DASHED`: In this option the streamlines are made up of a sequence of short segments giving them a dashed appearance. The segments can be animated to indicate the direction and speed of the flow.

`NO-SHOW`: The streamlines are not shown at all.

You may control the state of the streamlines (on or off) using the commands

type `streamlines =>ON`

and

type `streamlines =>OFF`

By default the potential streamlines are turned on and the limiting streamlines are turned off. It is usually too cluttered to have both potential and limiting streamlines turned on in the same display.

At any time, you may view the values of the streamline display parameters by giving the command

type `streamlines =>REPORT`

3.7 Adding the Boundary Layer Surface

The boundary layer is the region of flow near the hull in which viscous forces are important. HLLPNL lets you add the surface at the outer edge of the boundary layer to the display. This is a convenient way to determine the thickness of the boundary layer and to see how much of the propeller disk lies within it. Figure 4 is example of a display which includes a boundary layer surface; it is easy to see that the propeller disk lies partially within the boundary layer.

To add the boundary layer surface to the display, use the command

```
=>ADD BL-SURFACE
```

A report of all the default values for the boundary layer surface parameters is displayed, followed by the prompt

```
boundary layer surface =>
```

HLLPNL now expects you to adjust the boundary layer surface parameters to your liking. When you are done, give the command

```
boundary layer surface =>OK
```

The boundary layer surface requires data from a HLLSRF data file and a boundary layer data file. If either of these files has not already been read, you will be prompted for it now. Control then returns to the top level commands.

If you decide not to include the boundary layer surface after all, use the command

```
boundary layer surface =>CANCEL
```

to return control to the top level commands.

The boundary layer surface is described in the output file by a rectangular grid of panels. The panels only describe one half of the surface; they are then reflected in the centreplane to create the other half. The dimensions of the grid may be changed by the commands

```
boundary layer surface =>BOW-TO-STERN-NUMBER number
```

and

```
boundary layer surface =>GIRTH-NUMBER number
```

By default, the number of panels bow-to-stern will be 20 and the number around the girth will be 10.

The material properties of the boundary layer surface can be changed using the command

```
boundary layer surface =>MATERIAL
```

See Section 4 for a description of the appropriate sub-commands. By default, HLLPNL will not define a material for the boundary layer surface; SHUMP will then choose the material properties at random.

Like the propellers and the hull, SHUMP can display the boundary layer surface in five different ways. The normal and moving display modes may be set using the commands

```
boundary layer surface =>MOVING-DISPLAY-MODE display-mode
```

and

`boundary layer surface =>NORMAL-DISPLAY-MODE` *display-mode*

Section 5 describes the choices for *display mode*. The default for both the normal and moving display mode is SMOOTH.

You may control the state of the boundary layer surface (on or off) using the commands

`boundary layer surface =>ON`

and

`boundary layer =>OFF`

The default state is 'on'.

At any time, you may view the values of the boundary layer surface display parameters by giving the command

`boundary layer surface =>REPORT`

3.8 Adding a Boundary Layer Block

The boundary layer block is a two-dimensional SHUMP block which displays six boundary layer parameters on the surface of the hull: the momentum thickness, the shape factor, the tan of the cross flow angle, the boundary layer thickness, the skin friction coefficient, and the displacement thickness. For definitions of these parameters and details of the methods with which they are calculated, see Reference 7. A short description of SHUMP blocks is given in Appendix C.

Figure 5 is an example of a display containing a boundary layer block; it shows the momentum thickness with blue indicating large values and red indicating small values. The blue lines are the limiting streamlines (see Section 3.6). It is easy to see that the boundary layer thickens where the limiting streamlines converge.

To add the boundary layer block to the display use the command

`=>ADD BL-BLOCK`

A report of the default values for the boundary layer block is displayed, followed by the prompt

`boundary layer block =>`

HLLPNL now expects you to adjust the boundary layer block parameters to your liking. When you are done, give the command

`boundary layer block =>OK`

The boundary layer block requires data from a HLLSRF data file, a velocity data file, and a boundary layer data file. If any of these files have not already been read, you will be prompted for them now. Control then returns to the top level commands.

If you decide not to include the boundary layer block after all, use the command

`boundary layer block =>CANCEL`

to return control to the top level commands.

The boundary layer block is a rectangular grid of points on the hull surface. The dimensions of the grid may be changed by the commands

`boundary layer block =>BOW-TO-STERN-NUMBER` *number*

and

`boundary layer block =>GIRTH-NUMBER` *number*

By default, the number of points bow-to-stern will be 20 and the number around the girth will be 10.

The boundary layer block is placed a little bit above the hull surface so that it will be seen rather than the hull. If the number of grid points in the boundary layer block is too small, it may occasionally disappear behind the hull. This can be seen in Figure 5; there are three small patches near the keel where the hull is obscuring the boundary layer block. This problem can also occur in concave regions of the hull when the number of hull panels is too small.

SHUMP normally has nine different display modes for displaying blocks (see the description of the display modes for the flow block in Section 3.9); however, because the boundary layer block is two-dimensional and does not contain any vector quantities, only three of these display modes are appropriate. The normal and moving display modes may be set using the commands

`boundary layer block =>MOVING-DISPLAY-MODE` *display-mode*

and

`boundary layer block =>NORMAL-DISPLAY-MODE` *display-mode*

The three choices for *display mode* are:

`SHADED-SCALAR`: This is the standard display mode in which one of the boundary layer parameters is displayed in a shaded colour plot. The SHUMP block controls allow you to choose which parameter is displayed from a menu. It is the default for the normal display mode.

`GRID`: In this display mode the block grid is displayed as a wire frame. It is the default for the moving display mode.

`NO-SHOW`: The boundary layer block is not displayed at all.

You may control the state of the boundary layer block (on or off) using the commands

`boundary layer block =>ON`

and

`boundary layer block =>OFF`

By default the boundary layer block is turned off.

At any time, you may view the values of the boundary layer block display parameters by giving the command

`boundary layer block =>REPORT`

3.9 Adding a Flow Block

The flow block is a three-dimensional SHUMP block which displays the pressure and velocity fields around the hull. A short description of SHUMP blocks is given in Appendix C. Figures 6–9 are examples of displays including flow blocks. They are discussed below.

To add the flow layer block to the display use the command

```
=>ADD FLOW-BLOCK
```

A report of the default values for the flow block is displayed, followed by the prompt

```
flow block =>
```

HLLPNL now expects you to adjust the flow block parameters to your liking. When you are done, give the command

```
flow block =>OK
```

The flow block requires data from a HLLSRF data file, a velocity data file, and a boundary layer data file. If any of these files have not already been read, you will be prompted for them now. It also requires data from the then the POTFLO files RGRID.POT, RSOURC.POT, and PANPRP.POT. If these files cannot be found, an error message will be displayed and the flow block will not be included in the display. Once the files have been read, control returns to the top level commands.

If you decide not to include the flow block after all, use the command

```
flow block =>CANCEL
```

to return control to the top level commands.

The flow block is a rectangular grid of points on the hull surface. Two of the dimensions of the grid are set by data in the POTFLO file RGRID.POT; this is because the points must not come too close to the edges of the panels used to calculate the potential flow (see [8]). The third dimension, the number of points normal to the hull, may be changed by the command

```
flow block =>NUMBER-OF-Z-POINTS number
```

By default, the number of points normal to the hull will be 20.

SHUMP has nine different display modes for displaying blocks. The normal and moving display modes may be set using the commands

```
flow block =>MOVING-DISPLAY-MODE display-mode
```

and

```
flow block =>NORMAL-DISPLAY-MODE display-mode
```

The three choices for *display mode* are:

2D-SHADED-SCALAR: In this display mode, a shaded colour display of the pressure is shown on three two-dimensional sub-grids. One of the sub-grids is is a collection of points with x_1 constant, the second is a collection of points with x_2 constant, and the third has x_3 constant. This is the default normal display mode.

3D-SHADED-SCALAR: In this display mode the pressure is displayed throughout the grid. Adjacent points are connected with lines whose colour varies according to the value of the parameter being displayed. This display mode is usually too cluttered to be useful, unless the size of the block is very small.

2D-SHADED-VECTOR: This display mode is just like 2D-SHADED-SCALAR except that one of the components of the velocity is displayed on the three sub-grids. The SHUMP block controls allow you to choose which component is to be displayed.

Figure 6 are examples of the 2D-SHADED-SCALAR display mode. The SHUMP block controls have been used to turn off the sub-grid with x_2 constant. The propeller disk has been made transparent so that the flow block can be seen through it. The reduced velocity in the boundary layer can be seen clearly, as well as the region of reduced velocity over the propeller disk.

3D-SHADED-VECTOR: This display mode is just like 3D-SHADED-SCALAR except that one of the components of the velocity is displayed on the whole block. The SHUMP block controls allow you to choose which component is to be displayed.

2D-VECTOR-ARROWS: In this display mode the velocity vectors on each of the three sub-grids are represented by line segments. The direction of the line segment is parallel to the velocity vector and its length is proportional to the magnitude of the velocity. The SHUMP Advanced Block Control Panel allows you to change the length of the arrows and to animate them (when animated the arrows grow from zero length to full length, making it easy to determine the direction in which the velocity is pointing).

Figures 8 and 9 are examples of the 2D-VECTOR-ARROWS display mode. The SHUMP block controls have been used to turn off the sub-grids with x_1 and x_3 constant so that only a single two-dimensional sub-grid is displayed. In the close-up of Figure 9 the rapid reduction of the velocity magnitude at the hull surface can be seen clearly.

3D-VECTOR-ARROWS: This display mode is just like 2D-VECTOR-ARROWS except that the arrows are displayed at every point in the flow block.

2D-GRID: In this display mode the three sub-grids (constant x_1, constant x_2, and constant x_3) are displayed as a wireframe. The scalar and vector values are not used in this display. This is the default moving display mode.

Figure 7 is an example of a display which uses the 2D-GRID display mode. It is the same flow block as in Figure 6; the propeller disks and shafts have been removed for clarity.

3D-GRID: In this display mode the whole block is displayed as a wireframe. The scalar and vector values are not used in this display.

NO-SHOW: The flow block is not displayed at all.

Figure 6: *An example of a HLLPNL display including the hull, propeller disks, and a flow block. The flow block is displaying the X component of the velocity; low values are shown in red, high values in blue.*

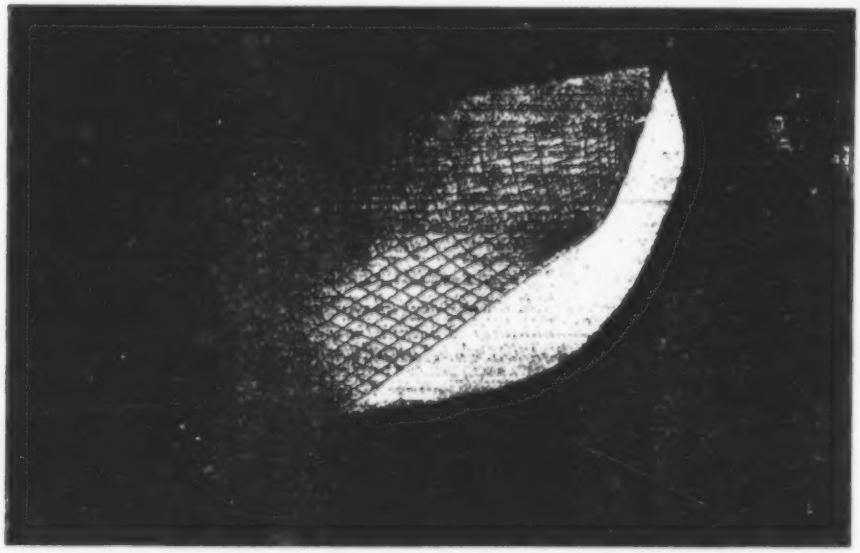

Figure 7: *The flow block of Figure 6 but using the* `2D-GRID` *display mode.*

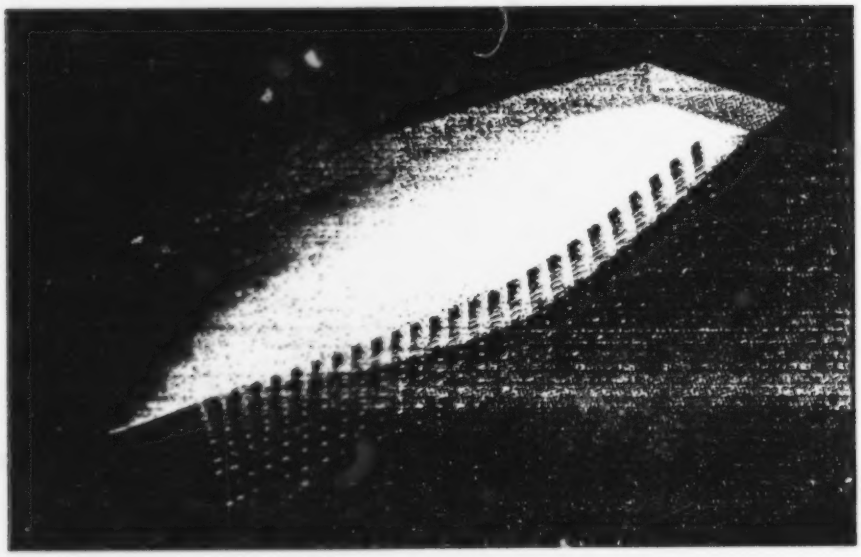

Figure 8: *A display of a flow block showing the vector arrows.*

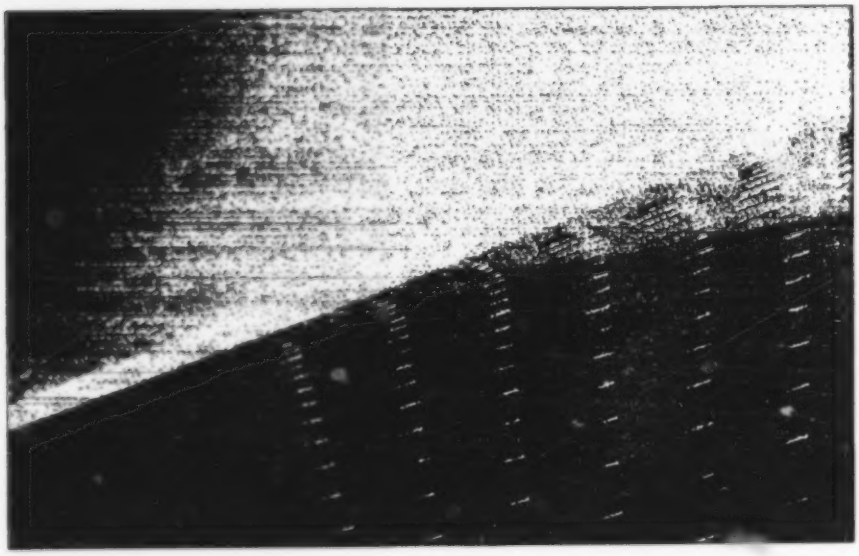

Figure 9: *A close-up of Figure 8.*

You may control the state of the flow block (on or off) using the commands

`flow block =>ON`

and

`flow block =>OFF`

By default the flow block is turned off.

At any time, you may view the values of the flow block display parameters by giving the command

`flow block =>REPORT`

4 Changing Material Properties

Several of the objects created by PRPPNL and HLLPNL are composed of panels: for example, the propeller blades, the hull, and the boundary layer surface. The appearance of such objects is controlled by giving them 'material properties'. These are described in Chapter 9 in the Graphics Library Programming Guide[9].

In PRPPNL and HLLPNL, material properties of an object may be changed by giving the command `MATERIAL`. You then enter a sub-command language with the prompt

`material =>`

Give the command

`material =>AMBIENT` *red green blue*

to specify the red, green, and blue components of the ambient property of the material. Each colour component must have a value between zero and one. Similarly, use the commands

`material =>DIFFUSE` *red green blue*

`material =>SPECULAR` *red green blue*

and

`material =>SHININESS` *shininess*

to specify the diffuse, specular and shininess properties. The value of *shininess* must be in the range zero to 128.

5 Display Modes for Objects Made of Panels

SHUMP can display objects composed of panels in five different ways; moreover, it is possible to choose a different mode of display for when the object is being moved and for when it is not. In both PRPPNL and HLLPNL, the command

object `=>MOVING-DISPLAY-MODE` *display-mode*

chooses the display mode for when *object* is being moved.

object =>NORMAL-DISPLAY-MODE *display-mode*

chooses the display mode for when *object* is not being moved. The choices for *display mode* are:

SMOOTH: This is the standard display mode in which the object appears smooth: see Figure 1.

SHOW-EDGES: In this option the panels comprising the object appear flat so that you can see their edges. It is unlikely that you will wish to choose this option.

WIREFRAME: The object is shown as a see-through wireframe. It is considerably faster to display the wireframe than the solid object. Consequently, this option is useful as the moving display mode on slower machines.

WIRE-EDGES: The object is displayed as a wireframe superimposed upon the solid object. This is the slowest display option, but is useful for highlighting the panels which comprise the object: see Figure 2.

NO-SHOW: The object is not shown at all. This is the fastest display option.

6 Concluding Remarks

This document has described two programs for producing SHUMP displays of propellers, hulls, and the flows around them. PRPPNL generates displays of propellers in isolation, and allows the inclusion of sheet cavitation extents as calculated by the program CAVITY. The geometric description of the propellers is obtained from the DREA propeller geometry data base.

HLLPNL creates complex displays of ship hulls including propellers, a waterplane, potential or limiting streamlines, a SHUMP block which displays boundary layer parameters over the hull surface, and a SHUMP block which displays the pressure and velocity vectors throughout the flow.

The displays generated are a significant advance over the two-dimensional line-plot graphics which, until now, have been used ate DREA for examiining the flow around ships.

Appendices

A The GETWRD Package

To allow you to change what will be added to the display files, PRPPNL and HLLPNL use a command language implemented with the GETWRD Package of subroutines[4]. The GETWRD Package allows a type ahead facility, abbreviated commands, command completion, help messages, and explicit error messages, providing a 'friendly' interface between you and the program.

The GETWRD Package defines six special characters.

1. The *delimiting character* is a space. All commands must be separated by spaces.
2. The *help character* is a question mark. For a help message and a list of possible commands, you may type a question mark whenever you are prompted for a command.
3. The *completion character* is a dollar sign. To have the current command completed from an abbreviated form, type a dollar sign. The default for a command is obtained by typing a dollar sign in lieu of the command.
4. The *delete word character* is an open angle bracket, <. To delete back to the beginning of the current command, type an open angle bracket.
5. The *delete letter character* is a backslash, \. To delete the previous letter in the current command, type a backslash.
6. The *abort character* is a caret, ^. To jump back to the highest level of command, type a caret.

At all levels of command the prompt for further input is an arrow, =>. To the left of the arrow appears a short indication of the input desired. To the right of the arrow appears the text of the command so far. For example, the prompt

```
ambient red? =>AMBIENT 0
```

asks you to type the red component of the ambient property of a material (see Section 4). You are at the third level of command, the previous two commands having been `AMBIENT` and the number 0. If you don't understand what is required at this point, type a question mark followed by a carriage return to receive the help message

```
Enter a colour component between 0 and 1.
```

Alternatively, to use the default value, you may simply type a dollar sign.

For more examples and a detailed description of the GETWRD Package see Reference 4.

B File Paths

PRPPNL and HLLPNL allow you to indicate a set of directories in which they will look for files. This is done by creating a file called `.filsub` (for Unix operating systems) or `init.filsub` (for VMS operating systems) in the your home directory ($HOME on Unix systems, SYS$LOGIN on VMS). Each line of this file should contain a single directory name. Whenever PRPPNL or HLLPNL open an existing file, they first look for the file on the connected directory, then in each of the directories in `.filsub` or `init.filsub` until the file is found.

For example, suppose you are running HLLPNL on a Unix system and that `.filsub` contains the entries,

```
/hllflo/hulls/
/test/newhulls/
```

When you give the command

```
=>ADD HULL
```

you are prompted for a file name. If you type the file name `canoe.hll`, then HLLPNL first searches for `canoe.hll` on the working directory. If it cannot be found, it looks for `/hllflo/hulls/canoe.hll`. If that fails, it looks for `/test/newhulls/canoe.hll`. If that fails, an error message similar to the following is written:

```
Error when opening "canoe.hll"
No such file or directory
```

B.1 Automatic loading of HLLSRF and Velocity Data Files

If the first line of a velocity data file is of the form

{HULL FILE:*file-name*}

where *file-name* is the name of a HLLSRF data file, then the HLLSRF data file will be read automatically. HLLPNL will then recognize that a HLLSRF data file has been loaded and will not prompt you for one. This is a convenient method for ensuring that the HLLSRF file loaded is the one for which the velocity data were calculated. If the first line of the velocity data file is not of this form, you will be prompted for the HLLSRF data file required by HLLPNL.

Similarly, if the first line of a boundary layer data file is of the form

{VELOCITY FILE:*file-name*}

then the velocity data file will be loaded automatically.

C SHUMP Blocks

A SHUMP block is a three-dimensional grid of points with dimensions $n_1 \times n_2 \times n_3$. The points in the grid are indexed by three integer coordinate values: x_1, running from 0 to $n_1 - 1$; x_2, running from 0 to $n_2 - 1$; and x_3, running from 0 to $n_3 - 1$. The points in the block may be displayed by choosing the Position from the Data Representation menu on the Control Panel.

Each point in the block may also store additional values which may be displayed. These values can be of two types: scalars (one floating point value), or vectors (a floating point vector whose components are defined in the body coordinate system. For the HLLPNL flow block, the body coordinate system is coincident with the hull coordinate system defined by HLLSRF: X runs from bow to stern, Y increases to starboard, and Z increases upwards.

Each scalar and each vector has a name: the names of the scalars are shown in the Active Scalar Menu beneath the Normal/Moving Display Mode button on the Control Panel. The naming appearing on the menu button is the active scalar. Similarly, the vectors names appear in the Active Vector Menu to the right of the Active Scalar Menu.

The individual components of vectors are also considered to be scalars so that they can be displayed in any way that a scalar can. The scalar which is used in the display is called the active scalar component: it may be the active scalar, or one of the three components of the active vector. The choice of the active scalar component is made using the Scalar Component Menu.

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SHUMP is a graphics program which displays three-dimensional scenes built from a hierarchy of simple objects: points, lines, panels, and so on. In this document two additional computer programs are described; they create SHUMP input files which display propellers, ship hulls, and the flows around them.

PRPPNL generates a SHUMP input file which includes a single propeller with the option of adding sheet cavitation extents on the back of each blade. The display may be animated to show the variation of cavitation as the propeller turns. The propeller geometry is obtained from the DREA propeller geometry database, while cavitation extents are those predicted by the computer program CAVITY.

HLLPNL generates a SHUMP input file which may include the hull, its propellers including sheet cavitation extents, streamlines, a surface at the edge of the boundary layer, shaded plots of boundary layer parameters at the hull surface, and displays of the flow field around the hull. The hull geometry is obtained from a HLLSRF representation, while the flow around it is obtained from the suite of computer programs HLLFLO.

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